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APPLIANCES AND METHODS FOR PEDIGREE POULTRY BREEDING.

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BULLETIN No. 159.

APPLIANCES AND METHODS FOR PEDIGREE POULTRY BREEDING.*

By RAYMOND PEARL and FRANK M. SURFACE.

The primary and most fundamental requirement in all breeding work, whether conducted for scientific or utilitarian purposes, is that at any stage of the work there shall be an exact knowledge of the ancestry (to as remote a degree as possible) of each of the individuals composing the breeding stock. A successful outcome of such work depends upon, among other things, an adequate system of keeping pedigree records. Not only must the pedigree records be accurate and systematic on paper, but they must also be *trustworthy*. To insure that they shall be trustworthy it is necessary that the concrete breeding operations be carried on in such systematic fashion that errors in or contamination of the pedigrees either will not occur, or if they do occur will be at once detected. That is to say, breeding operations must be so systematized that, for example, there cannot arise in the breeder's mind any doubt that the actual parents of a given individual are the animals which he supposes to be the parents.

Now so long as breeding operations are conducted on a restricted scale involving few individuals and pedigrees, the matter of keeping pedigrees is a tolerably simple one. But when the breeding stock rises to considerable numbers, as it very quickly does with small animals like poultry, the pedigree records and the whole machinery of breeding tend to become very intricate and complicated. With this increase in complexity inevitably comes an increased tendency towards error in the records. To gain and maintain simplicity and accuracy in the pedigree breeding of poultry involves the practical solution of a whole series of rather complicated problems of technique. In the breeding work at this Station working solutions of some of these technical problems have been reached. In every

* Papers from the Biological Laboratory of the Maine Experiment Station, No. 6.

instance the methods which have been devised and put into practice are known or believed to be different in some particulars from those which have been used by other workers along similar lines. Since these methods have proved to be useful in actual practice it seems desirable to publish them for the benefit of other breeders who may be interested in keeping exact pedigrees of poultry either for scientific or for practical purposes.

In order that a concrete idea may be gained of the nature of the technical problems which present themselves in pedigree breeding work with poultry, it may be well to trace the operations which demand attention in the production of a chicken of known ancestry. In the first place there must be a record on each egg of the hen which laid that egg. This record coupled with a knowledge of the male bird kept in the breeding pen with the hen which laid the egg in question gives the first step in the knowledge of the ancestry of the chick. But in order to get an exact record of the hen which lays a particular egg it is necessary to resort to the use of trap nests. The first technical problem which presents itself in pedigree poultry breeding is then to get a trap nest which shall be as nearly as possible ideal.

Having made a record of the egg the next problem is that of properly storing the eggs laid by the different hens until such time as a sufficient number shall have accumulated to fill an incubator.* It is obvious that under usual conditions enough eggs will not be laid in the same day to warrant starting their incubation at once. The eggs must be stored to make economical incubation possible. Furthermore it is not only highly desirable but almost absolutely necessary that the eggs originating from different mothers should be kept separate from the time they are laid so that at any time all the eggs which have come from a given mother since the last date of incubation may be found together. In order to attain this end various forms of egg sorting devices have been made. One of the best of these devices is an egg distributing table recently described by Rice and Lawry.** This egg distributing table, planned by

* It is assumed throughout this bulletin that incubators are used to hatch the chicks. This is not the proper place to enter upon a discussion of the relative merits of natural and artificial incubation. It need only be said that as a matter of fact few who have tried artificial incubation attempt to do any pedigree poultry breeding work on an extensive scale using hens as incubators.

** Cornell Experiment Station, Bulletin No. 248, pp. 219 and 220.

Professor Rice suffers from one defect, however, when it is used to hold eggs which are to be incubated. The defect consists in the fact that the eggs which are put on this table must be turned individually by hand from day to day. It is generally held that eggs awaiting incubation should be turned at least once every 24 hours. To turn a large number of eggs individually by hand involves a large amount of labor. It was formerly the practice of this Station to store the eggs awaiting incubation in an ordinary egg shipping crate and then to turn this crate from side to side or end to end each day. In that way all the eggs in the case would be turned daily without the considerable labor involving in handling each one of them separately. A mechanical turning device of this sort is put on the market by several poultry supply firms. It is practically impossible, however, to keep the eggs properly sorted as to mothers in such a crate. The desideratum is an egg distributing table on which the eggs can be mechanically turned all together.

Arriving at the actual incubation there presents itself in all pedigree poultry breeding work the matter of keeping the eggs originating from a given mother and the chicks which hatch from them together in the incubator so that the pedigree of the chicks at the time of hatching may be accurately recorded. This means that some sort of a device must be perfected for holding individual eggs and chicks of the same ancestry together in the incubator, and separate from all others.

After the chicks are hatched it is necessary to give each individual a distinguishing mark which will be a reference to the records wherein will be told its parentage. This necessitates methods of expeditiously and accurately handling chick leg bands.

Finally it is necessary to have a system of book keeping for keeping the pedigree records proper, which shall be accurate, easy of reference, and simple enough to be operated rapidly so that it can withstand the stress involved in the recording of 500 or 600 chickens all hatching at the same time.

The methods and appliances which have been devised in connection with the breeding work at the Maine Station bear upon each of the matters enumerated at one point or another. The remainder of the bulletin is devoted to detailed descriptions of these methods and devices.

THE NEW MAINE STATION TRAP NEST.*

The experience of the Station in trap-nesting large numbers of laying hens has served to bring out very clearly and forcibly what are the points to be desired in an ideal trap nest. These points are:

1. The nest must be so constructed that it will be impossible for a hen to enter it without causing it to close and lock. Whether a trigger, treadle, or spring device is used it must be so adjusted as to operate without fail. Furthermore the ideal trap nest should be so sensitive that the same nest will be adapted to hens of different breeds. This is a matter of particular importance in hybridizing work where one may have in the same pen, for example, Bantam and Cochin or Langshan hens. Obviously one cannot insure that in a mixed pen a Bantam hen will invariably go to a nest which is built especially for her. All the nests should be so constructed that they will operate equally well with either a Bantam or a Langshan, for example.

2. The nest must be so constructed as to be absolutely certain to lock after it has once been sprung, so that a second hen may not enter while the first one is on the nest. Practical experience shows that this is an important matter. Types of trap nests satisfactory in other ways, often fail at just this point and to see 7 hens and 3 eggs taken from the same trap nest at the same time, as has been the experience of the writers, is certainly not a recommendation for that particular type of nest.

3. It is desirable that a nest be built in two compartments; a rear compartment in which is the actual nest in which the egg is laid and a front compartment where the bird may stand after having laid and before she is taken out of the nest. If a front compartment is not provided there is great danger that

* This nest was invented by Mr. F. D. Sterry, Laboratory Assistant. While this bulletin was passing through the press the writers were informed that a trap nest involving some features similar to those in the nest here described has been in use for some time at the Utah Agricultural Experiment Station. Careful scrutiny of the bulletins of that Station fails to disclose any description of such a nest. Hence it is impossible to make any further acknowledgement of priority in the matter than what is here set down. In Bulletin 92 of the Utah Experiment Station is given on Plate 12, a photograph of the trap nest in use at that Station, but from this picture it is impossible to make out details of construction and operation.

the hen will break the egg by stepping on it after it is laid. Having two compartments, however, makes necessary a further provision. The nest must be so constructed that it will be impossible for a hen to lay in the front compartment without causing the trap to operate. A number of well known types of trap nests, including the nest which has formerly been used at this Station, which are otherwise very satisfactory, are so arranged that the trap is not sprung until the hen enters the second compartment of the nest. It has been demonstrated in our work here that in such a nest there will always be a number of hens which will lay in the front compartment of the nest without entering the rear compartment at all. Such a hen after having laid passes out of the nest without springing the trap, and hence makes it impossible to obtain a record for that egg. It has been the theory in the construction of two compartment nests of the type mentioned that the hen would go into the rear compartment where the nest proper was made in order to lay. This may be good theory but as a matter of actual fact hens will more or less frequently lay in the front compartment of trap nests of this type.

4. A trap nest to be ideal must be as simple as possible in construction and in operation. There are various types of trap nests on the market which no doubt are very satisfactory for the man who operates perhaps two or three such nests all told. These nests, however, are so complicated that it would be hopelessly impossible to operate and keep them in repair and working order for a flock of say 2000 hens. If one is to use trap nests on a large scale and continuously they must not only be simple in construction but must be such that it will take a minimum of time for the caretaker to empty and set them. Trap nesting is an expensive operation at best and it becomes more expensive the more complicated the nest is.

5. The nest should be durable and not likely to get out of order in such way that it will not operate satisfactorily.

The trap nest now in use at this Station was devised to meet these requirements and has been found to do so in a very satisfactory manner.

DESCRIPTION OF THE NEST.

The nest is a box-like structure, without front, ends, or cover, 28 inches long, 13 inches wide, and 16 inches deep, inside measure. A division board with a circular opening 7 1-2 inches in diameter is placed across the box 12 inches from the rear end and 15 inches from the front end. The rear section is the nest proper. Instead of having the partition between the two parts of the nest made with a circular hole it is possible to have simply a straight board partition extending up 6 inches from the bottom as shown in Figure 1. The partition with circular opening is, however, recommended. There are several reasons why the circular opening appears to be better than the straight board across the bottom of the nest. Experience has shown that a hen is less likely to go back and forth between the two compartments after she has laid when there is only the relatively small circular opening between them, than when there is a larger opening. This reduces the likelihood of broken eggs.

The front portion of the nest has no fixed bottom. Instead there is a movable bottom or treadle which is hinged at the back end (Figure 1). To this treadle is hinged the door of the nest. The treadle is made of 1-2" pine stuff with 1 1-2" hard wood cleats at each end (Figures 2 and 3) to hold the screws which fasten the hinges. It is 12" wide and 12 1-4" long. Across its upper face just behind the hinges holding the door is nailed a pine strip 4" wide bevelled on both sides as shown in Figures 2 and 3. The door of the nest is not made solid but is an open frame (Figures 1 and 3) to the inner side of which is fastened (with staples or cleats) a rectangular piece of 1-8" mesh galvanized screening (dimensions 8" x 9"). The sides of the door are strips of 3-4" beech stuff 12" long and 1 1-2" wide halved at the ends to join to the top and bottom of the door. The top of the door is a strip of hard wood 13" long and 1 1-2" wide, halved in 2 3-4" from each end. The projecting ends of this top strip serve as stops for the door when it closes (Fig. 1).



FIG. 1. Top view of trap nest closed.



FIG. 2. Trap nest with one side removed. Nest open.

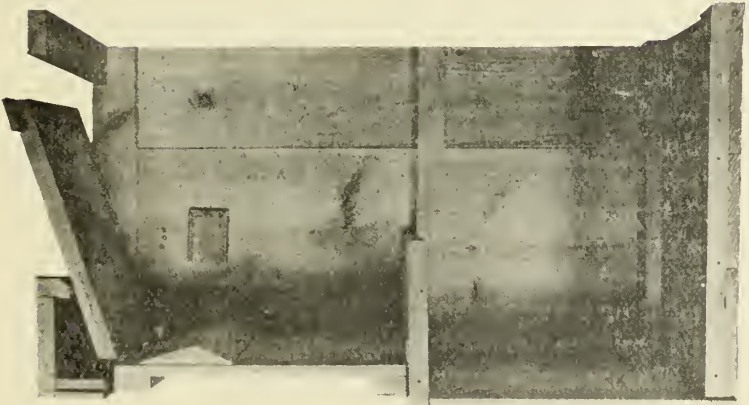


FIG. 3. Trap nest with one side removed. Nest closed.

The bottom of the door is a hard wood strip 10 1-4" by 4". The side strips are fitted into the ends of this bottom strip in such way as to project slightly (about 1-32") above the front surface of that strip for a reason which will be apparent.

When the nest is open the door extends horizontally in front as shown in Figure 2. In this position the side strips of the door rests on a strip of beech 1 1-2" wide beveled on the inner corner. This beech is nailed to a board 4" wide which forms the front of the nest box proper. To the bottom of this is nailed a strip 2" wide into which are set 4" spikes from which the heads have been cut (compare Fig. 2). The treadle rests on these spikes when the nest is closed. The hinges used in fastening the treadle and door are narrow 3" galvanized butts with brass pins made to work very easily. It will be recognized that the proper working of the nest depends to a very large degree on these hinges. It has been found necessary to have the hinges made to order in order to get any which would be sufficiently loose. This can be done, however, without any cost above the regular price of the hinges provided the order is placed for a considerable quantity at one time. Hinges such as those used in the nests at the Station may be obtained through the Rice and Miller Company, Wholesale Hardware, Bangor, Maine.

The manner in which the nest operates will be clear from an examination of Figures 2 and 3 which show a sample nest with one side removed to show the inside. A hen about to lay steps up on the door and walks towards the dark back of the nest. When she passes the point where the door is hinged to the treadle her weight on the treadle causes it to drop. That at the same time pulls the door up behind her as shown in Figure 3. It is then impossible for the hen to get out of the nest till the attendant lifts door and treadle and resets it. It will be seen that the nest is extremely simple. It has no locks or triggers to get out of order. Yet by proper balancing of door and treadle it can be so delicately adjusted that a weight of less than 1-2 pound on the treadle will spring the trap. All bearing surfaces are made of beech because of the well known property of this wood to take on a highly polished surface with wear. The nests in use at the Maine Station have the doors

of hard wood in order to get greater durability. Where trap nests are constantly in use flimsy construction is not economical in the long run. For temporary use the nest door could be constructed of soft wood.

The trap nests are not made with covers because they are used in tiers and slide in and out like drawers. They can be carried away for cleaning when necessary. Ten nests in a pen accommodate 50 hens, by the attendant going through the pens once an hour during that part of the day when the hens are busiest. Earlier and later in the day his visits are not so frequent. Considerable experience is needed in trap-nesting before one learns how best to manage the hens at different seasons of the year with reference to this matter of time of removal of the birds from the nests. The tendency with one beginning trap-nesting is to visit the nests too frequently, not allowing a sufficient time between visits. The frequent handling upsets the hens and increases the number of "floor eggs" (i. e., eggs laid outside the trap nests.) The aim should be to provide enough nests so that visits to them need not be made oftener than once an hour, even during periods of heaviest laying. There is need for exact observations to determine what is the average time spent by a "non-broody" hen on the nest.

To remove a hen the nest is pulled part way out, and, as it has no cover, she is readily caught, the number on her leg band is noted, and the proper entry is made on the record sheet. After having been taken off a few times the hens do not object to being handled; most of them remaining quiet, apparently expecting to be picked up.

EGG DISTRIBUTING AND TURNING TABLE.

As has been pointed out above (p. 240) it is desirable in poultry breeding work to have some arrangement such that the eggs laid by a particular bird may be kept together pending incubation, and at the same time be turned from day to day without too great an expenditure of labor. To attain these ends an egg distributing and turning table has been devised. A description follows of the table in use at the Station. It is, of course, possible to vary the dimensions at will from those given to meet special needs while retaining the general plan of the table.



FIG. 4. Egg distributing and turning table.

The table is tipped slightly from the horizontal point to give a view of the top. Note the 4 covers on the upper side with pin locks; the heavy braced base portion, and the light braces extending the length of the table above and below. The covers when raised are fastened to these longitudinal braces with wire hooks.

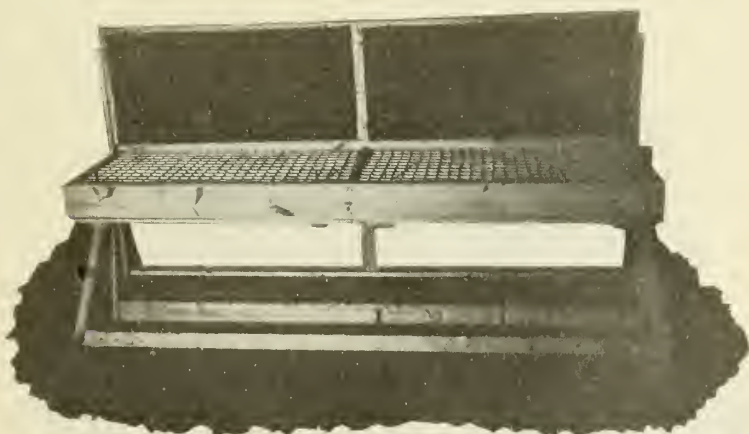


FIG. 5. Same view of the table as in Figure 4, but with the two covers on the side towards the observer raised. Note the compartments for the eggs (each vertical column of compartments—11 compartments in a column—receives the eggs from one hen whose band number is placed on the edge of the table at the end of the column); the lining of the covers; the small iron uprights which project through the covers when they are closed, and receive the locking pins.



FIG. 6. End view of table. Note heavy construction of base; central point on which the whole egg containing portion of the table turns.



FIG. 7. Showing the table locked in the vertical position 90° (approximately) from that shown in Figure 1.

It will be seen from the figures that the essential plan of the table is a very simple one. It consists merely in suspending an egg distributing tray on a pivotal axis so that it may be turned as a whole. It was desirable in the breeding work here to have an egg distributing table of as great capacity as possible, hence, it was made of large size and the egg trays were made double. In place of having the whole top of the table form one single compartment it was deemed desirable on account of the large size of the table to break it up into 4 parts each having a separate cover (cf., Figs. 4, 5, and 7). Each of these parts is of approximately the same depth as the length of an egg. In order to make compartments within the trays to hold the eggs from each individual breeding hen resort was had to the device of putting the ordinary pasteboard fillers from an egg shipping crate into the trays. These fillers were joined together in sufficient number with strong glue. Each cross row of compartments formed by these fillers may then be devoted to the eggs from a single bird and the number of that bird placed at the end of the row (cf., Fig. 5). In order to prevent the eggs from being broken when the table top was turned the trays were lined below and their covers above with extra thick deadening felt. This felt may be obtained from any dealer in builders supplies. In the table in use here each side is divided into 4 trays. The dimensions of these 4 trays are such that each will hold eggs from 25 breeding hens. Consequently, the whole of the top of the table contains eggs from 100 hens. The width of the table is such that there are 11 compartments for each hen so that 11 eggs from that hen may be stored before incubation.

As has been said the table top is made double. That is, the construction is the same as if two egg distributing trays such as those just described were placed back to back and fastened together. Thus, for example, in Figure 5 the table is shown with two of the trays on one side (say "side I") open. With the table in this position the covers of the trays of the other side ("side II") form in effect the bottoms of those trays. By making the distributing trays in this way the capacity of the table is doubled.

It naturally results that so large a table top when full of eggs is very heavy. Consequently it is necessary that the construction of the base on which this top rests and turns should be substantial. In the case of the machine here in use the base is constructed of 2 x 4 timbers thoroughly braced as shown in the figures and held together by bolts and draw plates. The heavy construction of the base is apparent from the figures. The axle or pivot at each end of the table top on which it actually turns is a short piece of 1" iron pipe set in a broad flange which is fastened to the center of the end of the table with screws. The pipe sets in a deep rounded slot in the upright of the base (cf., Fig. 6).

It will be noted from the figures that there are light longitudinal braces on either side of the egg distributing portions of the table. These braces serve two purposes: One, to furnish a support for the covers when they are lifted; the other to brace the upright pieces at the ends of the machine placed at right angles to the table top proper. At one end of the table these upright pieces and the boards forming the ends of the trays each have a 1-2" hole bored through them. When in the proper position these holes receive a locking pin working in the base frame at the same end of the table.

The manner in which the machine is used is as follows: The eggs when brought from the breeding pens are sorted into the machine according to the numbers of the hens at the ends of the columns of compartments. These hen numbers are arranged on the trays to correspond with the order of the breeding pens in the poultry houses. After the eggs from the hens belonging on one side of the machine have been distributed the covers of that side are closed down and locked with the pin locks shown in the figures and the whole table top is turned on its longitudinal axis until the other side is brought uppermost. Then the eggs are sorted into that side. Usually at one other time during the day the whole table top is given either a half turn or a quarter turn from its previous position and locked in place. The appearance of the machine when it is given a quarter turn from its usual position is shown in Figure 7.

It will be seen that this table meets the requirements stated at the beginning. It enables one to distribute the eggs with ease

and at the same time to turn all the eggs waiting incubation at one operation instead of having to handle each of them separately. The table has been found to be very satisfactory in actual practice. The dimensions of the table in use here are given in the following table.

TABLE OF MEASUREMENTS OF EGG DISTRIBUTING TABLE.

Length of egg containing portion.....	8 ft.	1 inch
Breadth of egg containing portion.....	3 "	9 $\frac{3}{4}$ "
Height of table top above floor.....	3 "	2 "
Thickness of whole egg containing portion....		7 $\frac{3}{4}$ "
Depth of each tray (inside).....		2 $\frac{3}{4}$ "
Length of covers.....	3 "	11 $\frac{1}{2}$ "
Breadth of covers.....	1 "	10 $\frac{1}{2}$ "
Capacity 2200 eggs and 200 "mother" hens.		

PEDIGREE INCUBATOR BASKETS.

It is necessary in pedigree poultry breeding work that the eggs from a given hen should be kept together, at least during the last days of incubation, and in such way that the chickens which hatch from these eggs cannot be separated and mixed with others after hatching. This end is usually attained by the use either of so-called pedigree trays which may be substituted for the ordinary egg trays of the incubator, or of small wire baskets placed on the ordinary egg trays of the machine. The objection to the use of the so-called pedigree trays made by the incubator manufacturers is that they allow but few different pedigrees to be carried in the same incubator at the same time. It is difficult with these trays to incubate economically. The wire basket scheme has in consequence been adopted in the breeding work here.

The baskets which are used and which have been found to be very convenient are illustrated in Figure 8.

These baskets are made of 3-8" mesh galvanized wire and have the following dimensions: Length 7 3-4"; breadth 5 1-4"; depth 2 3-4". This size makes it possible to put 12 of the baskets in each tray of a No. 3 Cyphers Incubator (360 egg size) which is the incubator used at the Station. Furthermore the size of the baskets is so calculated that a tray may be drawn out and put back into the machine without having the baskets

hit the thermostat. Around the top of the basket is put a strip of galvanized iron folded down over the edge as shown in the figure. This galvanized strip is soldered at the corners. The purpose of the strip, which is an important feature, is to give the whole basket stiffness and maintain its shape under the rough handling which such baskets must receive when used in breeding operations on a large scale.

One of these baskets of the dimensions given will hold 11 eggs without undue crowding. When it is desirable, as is often the case in hybridizing work, to incubate a smaller number of eggs from a given female than 11, it is convenient to subdivide the baskets. This is done by the insertion of a removable wire partition such as is shown in the right hand basket in the figure. This partition is cut the right size to fit easily into the basket and is held in place by three twisted wires; one on each side and one on the bottom.

There is attached to each basket, or, in the case of the subdivided baskets to each end, a wired tag on which is placed the band number of the hen whose eggs go into the basket.

At the time when the eggs are turned for the last time before hatching covers are placed over the baskets. One of these covers is shown in Figure 8. It is a very simple affair consisting of a piece of galvanized wire screening bent over a form of suitable size. These covers may be made to fit so tightly that they will not be pushed off by the chickens as they hatch. In the case of an especially crowded basket, however, it is sometimes desirable to wire the cover on in order to prevent the escape of any of the chickens as they hatch.

CHICK LEG BAND BENDER.

As the chicks are hatched there is immediately attached to each one a numbered leg band. In the work here the ordinary type of flat aluminum composition metal chick band is used. These bands come from the manufacturer as a flat strip of metal with a number on one end. Before these can be put on the chicks they must be bent into a circular form. This bending is usually done by hand with a considerable expenditure of time; particularly when, as is frequently the case, the composition metal of which the bands are made is unduly hard and stiff. Furthermore in bending these chick bands by hand it is difficult

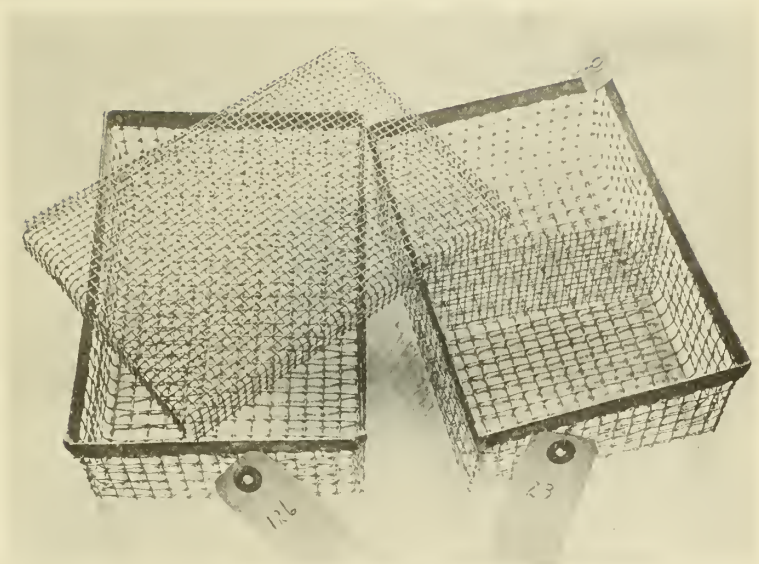


FIG. 8. Pedigree incubator baskets.



FIG. 9 Chick leg band bender.

to get a uniform bend on each one. In consequence a good deal of time is often lost in putting them on the legs of the chicks. It seemed desirable to have some sort of mechanism which should bend these bands more rapidly and uniformly than could be done by hand. A device to accomplish this purpose was invented by Mr. F. D. Sterry, Laboratory Assistant, and is shown in Figure 9.

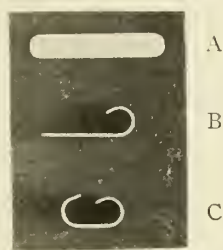


FIG. 10. Chick leg bands. A. As the band comes from the manufacturer. B. Band bent at one end. C. Band bent at both ends as recommended.

The construction of this device will be plain from the figure and an account of its operation. The leg band which is to be bent is inserted between the two fixed posts *a* and *b* with its end against the adjustable stop *d*. The post *c* on the movable bar to which the operating handle is attached then engages the outside of the band. By rotating this arm about the axis on which it is pivoted, the leg band is rolled around the post *a* and given the desired bend at one end (Figure 10B). This post *a* is filed to exactly the size which has been found by experience to be best for the bend in the band. Having bent one end of the band by simply reversing it and going through the same operation a similar bend may be put in the opposite end, giving the band finally the appearance shown in Figure 10C.

It has been found desirable to have these chick bands bent at both ends because they can then be put on the leg of the chick with much greater speed and uniformity of fit. To put one of these bands bent at both ends on the leg one simply takes it with the thumb and forefinger bearing on the two bent ends and slips the chick's leg into the band on one end and then by compressing the thumb and finger the band rolls around and

makes a neat joint. Actual experience has shown that chicks can be banded much more rapidly with the bands bent in this way than if they are bent only at one end. The apparatus for bending can be very easily constructed by any mechanic.

A SYSTEM OF KEEPING PEDIGREE RECORDS.

There are probably as many systems of keeping pedigree records as there are breeders who are interested in such records. Each breeder's particular interests or needs lead to the adaptation of records to meet these needs. There is reason to believe, however, that not a few breeders keep their pedigree records in so *unsystematic* a manner that, on the one hand, a great deal of time and labor is lost in tracing pedigrees and in entering new, and, on the other hand, there is great likelihood of error occurring in the records themselves because of the unwieldy character of the method according to which they are kept. All will agree that the thing to be desired in such a system of records is that any given pedigree or step in a pedigree may be looked out or entered with the least possible expenditure of time and labor and the greatest possible accuracy. The system of record keeping in use in the breeding work here is thought to realize this ideal very well. It has been tested under conditions calculated to put any record system under the severest kind of strain and has stood the test satisfactorily. Its simplicity is its great recommendation.

It should be said that for suggestions regarding the keeping of pedigree records some of which are embodied in the system to be described the authors are indebted to Dr. Leon J. Cole, Instructor in Zoology at Yale University, formerly Chief of the Division of Animal Breeding and Pathology in the Rhode Island Experiment Station. In particular Dr. Cole brought to our attention the usefulness of the "mating number" idea (cf., p. 264) which is the fundamental starting point in the system of record keeping here described. For the sake of historical accuracy it should be stated that this idea of using "mating numbers" is essentially that proposed some years ago by Galton * for keeping human pedigree records.

* Galton, F. Pedigrees. Nature, Vol. 67, pp. 586-587, 1903.

GENERAL POINTS REGARDING PEDIGREE RECORDS.

For keeping the pedigree records in the breeding work of the Station the loose leaf system has been adopted. All records are kept on sheets of uniform size (5 x 8 inches) which are readily removed or inserted in a patent type of binder which is used. After examining into the relative merits of loose leaf and card systems and seeing both in operation in the keeping of laboratory records it was decided that the loose leaf system possesses distinct advantages over the card system for the keeping of pedigree records. Some of these points of advantage may be enumerated. Perhaps most important of all is the greater compactness and portability of records kept on a loose leaf system. A record book 5 x 8 inches in size is much more easily carried about from incubator cellar to breeding pens or laboratory than is a tray containing index cards. Furthermore the thin paper of the loose leaf sheets keeps down the bulk of the records to a minimum as they accumulate. The supposed inferiority of the loose leaf system as compared with the card system in the matter of inserting or removing sheets has been found in actual experience to be imaginary rather than real. The sheets can be inserted or removed from a loose leaf binder just as quickly as cards can be taken from a drawer in which they are locked.

In keeping the records sheets of different colors are used for different specific classes of data. For example, the mating sheets (cf., p. 264 below) are printed on orange paper; incubator records on pink paper; autopsy records on blue paper, and so on. This point of using different colored sheets for different parts of the records is a valuable aid in quickness of reference.

It will be noted in the account of the system of record keeping which follows that an effort is made at every possible point to make the numerical features of the records run in continuous series. This is a very important matter, although it might not be so considered by one who had not had experience in this particular kind of work. If any system of keeping pedigree records is used which involves giving the chicks when they are hatched band numbers which do not run in consecutive series it will be necessary to stamp with a die the leg band for each

individual chick. Leg bands consecutively numbered from one to any number desired may be purchased for a very slight advance over the price of blank leg bands. When one hatches several thousand chickens the labor which would be involved in numbering these bands individually by hand would be very great. But the matter of the total amount of labor involved is not the only one to be considered. There is also the time factor which must be taken into account. This will be plain if it be considered that one may have say 500 or 600 chickens hatching on the same day. It would be practically impossible under ordinary conditions to stamp a distinctive leg band for each one of these individual chicks as they were hatching and keep the book records of the pedigree straight at the same time. These considerations make it necessary to use for chick leg bands consecutively numbered bands which can be bought already numbered and have merely to be put on and recorded in the book at the time of hatching.

Similar considerations apply to the leg bands of adult birds. In the work of the Station a great deal of attention is being paid to the subject of egg production and its improvement by breeding. From 500 to 800 laying hens are tested in trap nests each year. The keeping of these egg records with accuracy involves careful attention as to method. A prime requisite both for accuracy and economy (in the matter of labor) is that the leg band numbers of these birds in the laying tests shall run consecutively, through the whole flock and in each separate pen. This means of course that a bird's adult band number will not be the same as its chick band number except by the rarest of accidents.

In connection with the matter of consecutive numbers it may be said that in keeping the breeding and egg records in the work here, an automatic numbering machine has been found to be an extremely valuable mechanical aid.

THE MATING SHEET.

The fundamental starting point of the present system of records, as has been implied above (p. 262), is the use of what will be spoken of throughout as "mating numbers." The idea is this: When a particular hen and cockerel are put together

in a mating pen there is given to the mating so formed an arbitrary number called the mating number. While these mating numbers are perfectly arbitrary they are taken consecutively for reasons of convenience referred to in the preceding section. The mating number itself gives no statement of the pedigree but it forms one element of an index wherewith the pedigree can be very quickly and easily looked out. At the time when the mating is made up and the mating number is assigned, there is prepared a mating sheet so-called, which is shown in Figure 11 somewhat reduced. *The purpose of this mating sheet is to show in one place the individuals which comprise a given mating and all the progeny which arise from that mating.* The mating sheet might with equal propriety be called a "family sheet" since it would include in human pedigree records a given pair of parents and all their children. Similarly the mating number might be called the "family number." It corresponds to the family name in a human family for a *single generation*. It differs from a family name in that it is not transmitted either through male or female lines. Instead every new mating receives a new mating number.

[illegible]

FIG. 11. Facsimile of mating sheet, reduced one-half.

With the general idea of the purpose of mating numbers in mind the significance of the arrangement of the mating sheet as

shown in Figure 11 is plain. At the top of the sheet there is placed the "Parentage;" that is, the designating band numbers of the two individuals that compose the mating which is characterized in the records by the mating number at the upper right hand corner of the sheet. For convenience an arbitrary rule is made to put the band number of the male bird above that of the female. The date at the top of the sheet is the date at which the mating was made; that is, it is the date on which the two mated birds were put together in the mating pen. There is also placed at the top of the sheet the number of the pen in which these mated birds were kept. Below the horizontal double line on the mating sheet the space is devoted to the progeny which arise from the mating. In the first column is put the chick band number of each chick hatching from this mating. As has been said the chick leg bands are numbered consecutively. They come from the manufacturer in bundles of 25. No attempt is made in banding the chicks to sort these so that on any given mating sheet the numbers shall run consecutively. They are simply taken within the bundle of 25 at random. The second column provides space for the insertion of the adult band numbers for such of the chicks coming from the mating as are kept over as adult birds, either for egg record tests or, in the case of cockerels, for breeding purposes. In the third column is recorded the sex of each chick as soon as it can be determined. In the fourth column is placed the date of hatching of each chick. This column is of the proper width to take the ordinary band dating stamp.

The fifth column which is headed "Matings" on the sheet is intended to contain a very important part of the pedigree records. *In this column are inserted the mating numbers of those matings into which each individual may in its adult life enter.* Through the mating numbers in this column the connection is made between the parent individuals at the top of the page and all their grandchildren and progeny farther removed. An example will illustrate how this is done: Suppose that an individual having an adult band number 244 has the number 622 in the column headed "Matings." This will signify that to look up the records of the offspring of bird No. 244 one must turn to mating number 622. On that mating sheet will be found a record of all the immediate offspring of this bird arising

from the particular mating 622. But the parents of bird 244 are given on the sheet where 244 itself appears as a chick and as an adult. Hence, there is formed a direct connection in the records between all the individuals in a line of descent. All ramifications of a pedigree may be followed with ease, and very quickly. The mating numbers inserted in the column headed "Matings" are inclosed in brackets.

In the last column headed "Remarks" are put brief notes of a miscellaneous character, such as references to autopsy records and the like.

In addition to the mating sheet just described it is often desirable to make out also for each mating on an ordinary horizontal ruled sheet of the same size punched to go into the same note books a general account of the mating with a statement of the specific purpose for which this mating was made. This record should include all pertinent data regarding the mating. The sheet on which this record is made should have the mating number placed in the upper right hand corner.

DESCRIPTIVE CATALOGUE OF BREEDING STOCK.

For each individual used in breeding there is made out a record sheet which sets forth the data regarding this individual which are regarded as of importance in the breeding work. These sheets, which are of uniform size with all the other record sheets, bear in the upper right hand the band number of the individual. They are filed consecutively in the order of these numbers. On the sheet for a particular bird are recorded, besides its band number, the following data.

1. The mating number of the mating from which the bird to which the sheet pertains *originated*.

2. All mating numbers of matings into which this bird as an adult *enters*.

3. The chick band number of the bird.

4. A description of the bird. This will vary in extent and in character with the purpose for which the bird is used as a breeder.

These records are kept on ordinary sheets with horizontal rulings. No specially ruled blank form is necessary.

INDICES.

Besides the two kinds of record sheets already described—the mating sheet and descriptive catalogue sheets—there is necessary in the system of pedigree records here described only one other type of record. It is necessary for the most convenient operation of the system (though not for its completeness or accuracy) that there be prepared certain indices. The underlying reason which makes these indices necessary is that it is most simple and convenient to find any desired point in a set of figures if those figures are arranged in consecutive order. It is therefore desirable, or indeed necessary, that a person approaching these pedigree records from any point—whether chick, adult bird or mating—should find the numerical designations of the individuals in the class with which he starts arranged in consecutive order, with proper cross references to the other classes. To attain this result it is necessary to have the following indices.

1. *The “mother-mating” index.* On this index which occupies a single foolscap sheet and is fastened to a board to facilitate handling in the incubator cellar, the band numbers of all the hens in the breeding pens (potential “mother” hens) are arranged in columns in consecutive order. In parallel columns there is set down over against each hen’s number the number of the mating to which she is a party. This index is used when the pedigreed chickens are leg banded after hatching. Each egg from the breeding pens is marked when gathered with the number of the hen which laid it. When the eggs from any given hen are set in the incubator the tag on the end of the pedigree basket (cf., p. 258) is marked with the hen’s (i. e., the mother’s) number. After hatching when a basket containing chickens is taken from the incubator for the banding this mother’s number is looked out on the index at a glance, and the corresponding mating number tells at once where to open the book containing the mating sheets in order to enter the band numbers of the chickens. With the aid of this index sheet one person can enter chick records approximately as fast as two persons can band the chickens.

2. *The “chick-adult-mating” index.* In this index all chick band numbers are arranged in columns in consecutive order, on

sheets of foolscap size. In parallel columns there is space provided in which to set over against each chick band number (a) the adult band number of the same individual and (b) the mating number of the mating from which that individual originated. The need for this index is as follows: Suppose one picks up a chick on the range with a particular band number and desires to know its pedigree. The question which immediately presents itself is: "What was the mating number of the mating from which this chick arose?" It obviously would be a great task to hunt through all the mating sheets until one came upon this chick band number. But if there is arranged an index in which the chick band numbers are arranged in consecutive order, and having in parallel columns the mating number of the mating from which each chick arose it will clearly be possible to turn very quickly to the mating sheet corresponding to any individual chick number. Having the proper mating sheet in hand it is the simplest of matters, as has been shown above, to trace the entire pedigree. The mating number in this index are most conveniently entered at the time of hatching. The adult numbers are entered when the bands are changed.

3. *The "adult-mating" index.* In this index the adult band numbers of all birds are arranged in columns in consecutive order. In parallel columns is put the mating number from which each bird arose. This index is only useful for special purposes. Ordinarily its purpose will be served by the descriptive catalogue sheets.

It will be seen that, with these indices and the mating sheets described above, from whatever standpoint one approaches the records with the desire of looking out the pedigree of any bird the task will be found easy. If one starts with the chick to look out the pedigree the point of departure is the "chick-adult-mating" index. This index refers to the proper mating sheet. If one starts from an adult bird either the "adult-mating" index or the descriptive catalogue refers again to the proper mating number. The mating sheets themselves are arranged in the book in consecutive order so that to turn to a given mating sheet is no more trouble than to turn to any given page of a book.

column is recorded the absolute number of embryos which "died in the shell;" i. e., sometime during incubation. These are, in other words, the fertile eggs which fail to hatch. In the sixth column is recorded the absolute number of chicks which hatch in a given batch, and the following column gives the percentage of the fertile eggs which hatch. The following column headed "Died in three weeks" records the number of chicks arising from the original batch of eggs which hatched out but died sometime within three weeks after hatching. The two following columns give respectively the number of the incubator and the brooder in which this given batch of eggs and the chicks arising from it were handled. At the right hand edge of the sheet is left a space for any notes regarding particular lots of eggs which it may be desirable to record.

It may perhaps be well to point out that this hatching record forms no absolutely necessary part of the pedigree records. It does, however, include data of the sort which every practical breeder must have. The great practical value of the data which come out of hatching records kept in this way in their bearing on the general problem of building up the utility characteristics of the flock by breeding will be discussed in another place.

It will be noted that this sheet is well adapted to keeping the history of individual eggs when for any reason it is desired to do this in an experiment. When used in this way a single line will of course be devoted to a single egg instead of to a "clutch" of eggs as described above. When used in this way the percentage columns would naturally be used as "summation" columns for entering totals and sub-totals.

INCUBATOR RECORDS.

When pedigreed eggs are set in incubators it is necessary that a record regarding the eggs put in should be kept. These records are made on sheets of the sort shown in Figure 13.

	INCUBATOR NO.		IN INCUBATOR					2
	HATCHED		TESTED		TESTED			4
	MOTHER	EGGS IN	INFERTILE	DEAD IN SHELL	HATCHED	MATING	REMARKS	6
								8
								10
								12
								14
								16
								18
								20
								22
								24
								26
								28
								30

FIG. 13. Incubator record sheets. In facsimile, reduced one-half.

At the top of these incubator records are placed the following data: The number of the incubator; the date on which the eggs were put in; the date on which they hatched, and the date or dates when they were tested. Below the double horizontal line one horizontal line is given to the eggs from each breeding hen whose eggs go into that particular incubator. In the first column is recorded the mother's band number; in the next column the number of eggs from that hen which go into the incubator. In the next two columns are recorded the number of eggs from that hen which prove to be infertile or, being fertile, produce embryos which die before hatching. In the next column is given the number of chicks which hatch from the given lot of eggs. Finally, in the column headed "Mating" is recorded the mother's mating number. It will be seen that this at once connects the incubation records with the rest of the pedigree record system. In the final column is left a space for notes of a character not otherwise provided for on the sheet.

It will of course be apparent that the incubator records here discussed are quite distinct from those which have to do with the performance of the incubator in regard to temperature, humidity and the like. Such records are not peculiar to pedigree breeding work and consequently will not be discussed in this paper.

PEN RECORDS.

For some purposes it is desirable in breeding work to have records which will enable one to tell at once just what birds are in a given mating pen. In the work here such records have been kept on ordinary horizontally ruled loose leaf sheets of the same size as the other record sheets. It may be said in this connection that separate pen records of this kind are of relatively little use in such a system of keeping breeding records as that here outlined. In making out one's mating numbers at the beginning of the breeding season it is not only easy but it is the natural thing to have the mating numbers within a given pen run consecutively. The result of this is that by going through the book containing the mating sheets one gets with great ease the pen records directly from the mating sheets. For the matter of completeness, however, it is probably desirable in all cases to have separate pen records.

ADVANTAGES OF THE MATING NUMBER SYSTEM OF PEDIGREE RECORDS.

In closing some of the more important advantages of the mating number system of keeping pedigree records may be summarized as follows:

1. The parents and all offspring related to any given mating are all brought together in the record books. Brothers and sisters appear on the same sheet and with their parents.
2. Starting at any point it is equally easy to go forward or backward on a pedigree or to go into collateral branches. This facility depends on two fundamental facts; viz., (a) that the individual *mating* is the natural unit in breeding operations, and (b) that on the same sheet on which the record of any individual appears there appears also the number of the mating from which this individual originated on the one hand, and the numbers of the matings in which it takes part on the other hand. In other words, whether on mating sheet or in the descriptive catalogue, the connection of the individual both with what is behind and what is beyond in the pedigree is always maintained.
3. Owing to the fact that designating numbers of individuals do not in this system attempt to carry the pedigree within them-

selves, there is no tendency for these numbers to become complex. Complexity in designating numerals, and accuracy in entering and extracting pedigree records are very difficult things to have in common.

4. The system of pedigree records described is in effect a double entry one. This feature makes for accuracy because it makes it possible to detect errors which may get into the records.

5. The system is a very elastic one. By making very slight changes in matters of detail it can be adapted to keeping pedigree records in any kind of breeding work with either plants or animals, or as has been pointed out by Galton (*loc. cit.*) to keeping human family records.

6. Most important of all is the simplicity of the system. It is so simple and straightforward that once its essential features are grasped it is only by gross carelessness that an error in the records can be made.

